STEC™ Industrial Grade USB Flash Drive
1GB to 8GB Capacities

SLUFDxxxU2TU(I)

Capacity: 1GB - 8GB

USB 2.0 Compliant

LED activity indicator

Customizable for logo/graphic design

High Reliability:

- Advanced Wear-Leveling
- BCH ECC Engine corrects up to 16 bits errors per 1 Kbyte
- Automatic Bad Block Management
- Single Level Cell (SLC) NAND Flash Memory
- 10 Year Data Retention

NEBS Level 3 compliant for ESD

- 8KV Contact, 15KV Air

Lot Traceability

Commercial and Industrial Operating Temperatures Available

RoHS-6 Compliant

www.stec-inc.com

General Description

The STEC™ Industrial Grade USB Flash Drive is more than just portable storage. Tailored for industrial applications that require high reliability and data throughput, it provides non-volatile, industrial grade solid-state storage in a thumb-drive package. In addition, labeling allows for lot traceability and complete info on the Bill of Materials.

The industrial grade USB flash drive is available in an ESD rated enclosure (with LED light indicator) for applications that require NEBS Level 3 compliancy. The ESD-rated enclosure has been tested for immunity from ESD for 8KV contact and 15KV air.

The industrial grade USB flash drive is manufactured with STEC's state-of-the-art, USB 2.0 flash memory controller, providing high data reliability and endurance. Flash management software embedded in the controller emulates a hard disk, enabling read/write operations that are identical to a standard, sector-based hard disk. Sophisticated wear leveling algorithms ensures greater flash endurance, while automatic bad block management and a built-in ECC Engine ensure the highest data reliability. Based on a BCH error correct algorithm, the ECC engine can correct up to 16-bit errors per 1 Kbyte.

The industrial grade USB flash drive with its high performance, high reliability and low cost per megabyte is the product of choice in embedded applications, such as Gaming, POS Workstations, Networking Equipment and Industrial PCs.

The industrial grade USB flash drive is fully customizable to add a company logo, graphic design, or text. In addition, STEC offers value-added services to OEM customers, such as pre-loaded content and controlled Bill of Materials.

Ordering Information: USB Flash Drive

Part Number	Capacity
SLUFD1GU2TU(I)	1 GBytes
SLUFD2GU2TU(I)	2 GBytes
SLUFD4GU2TU(I)	4 GBytes
SLUFD8GU2TU(I)	8 GBytes

Legend:

- **SL =** STEC standard finished product
- **UFD =** USB flash drive form factor
- **1G/2G/4G/8G =** 1GB / 2GB / 4GB / 8GB capacity
- **U2T =** STEC's USB flash memory controller (2nd Generation)
- **U =** RoHS-6 compliant
- **Part numbers without (I) =** Commercial temperature range (0ºC to 70ºC)
- **I =** Industrial temperature range (-40ºC to 85ºC)

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1.0 Introduction

This datasheet includes the following sections:

- *Product Specifications* covers the most referenced specifications, such as mechanical dimension, signal description, and performance.
- *Theory of Operation* explains the industrial grade USB flash drive block diagram and flash management features.
- *Environmental Specifications* characterizes the recommended operating conditions, reliability parameters and shock, vibration and humidity parameters.
- *Electrical Specifications* describes the absolute maximum ratings and AC/DC characteristics.
- *Product Marking* describes the marking on the industrial grade USB flash drive.

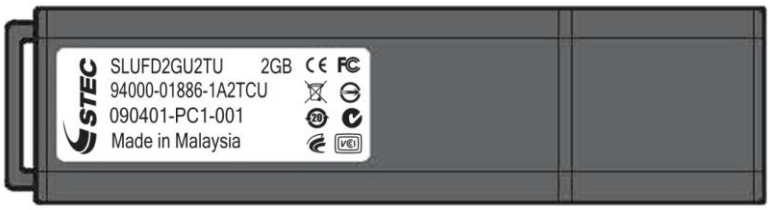

Figure 1: Industrial Grade USB Flash Drive

2.0 Product Specifications

2.1 Mechanical Dimensions

Table 1 and Figure 2 show the mechanical dimensions of the industrial grade USB flash drive with ESD-Rated Enclosure.

Table 1: Mechanical dimension

Parameter	ESD-rated enclosure
Length with Cap	66.1 mm (2.602 in) Max
Width	16.60 ± 0.20 mm (0.654 ± 0.008 in)
Height	7.02 ± 0.20mm (0.276 ± 0.008 in)

Units: mm (in)

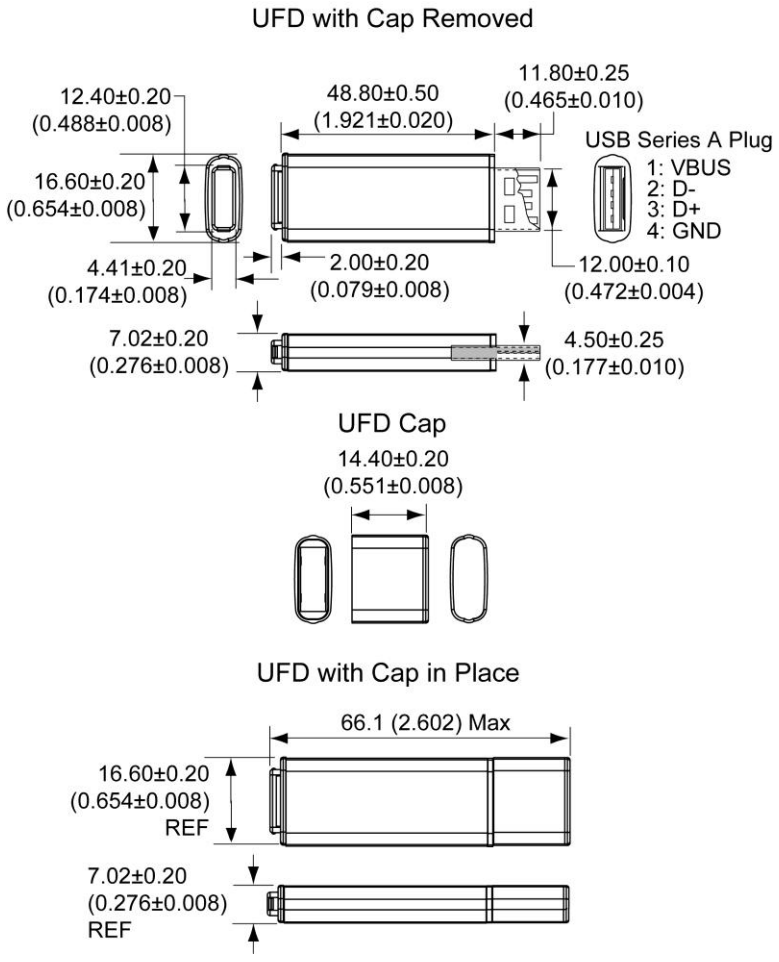

Figure 2: Mechanical dimensions-UFD ESD-Rated enclosure

2.2 Pin Assignment and Description

Table 2: Pin Assignment and Description

Pin Number	Signal Name	Type	Description
1	VBUS	Power	Bus voltage supply
2	D-	I/O	Data line –
3	D+	I/O	Data line +
4	GND	Ground	Ground

2.3 Performance

The industrial grade USB flash drive is USB 2.0 high-speed (480Mb/sec) and USB 1.1 full-speed (12Mb/sec) compliant. Measured performance for high-speed can be found in Table 3.

Table 3: Read/Write Performance

Parameter	Value
Sustained Read	up to 30 MB/sec
Sustained Write	up to 20 MB/sec

2.4 LED Functionality

The industrial grade USB flash drive with standard enclosure incorporates a LED activity indicator that functions as described below:

- LED flashing: Drive is transmitting/receiving data or is identification process
- Default LED colors: Blue

2.5 Power Consumption

The power consumption currents listed in Table 4 are for reference only. Power consumption may change according to flash memory used.

Table 4: Power Consumption

Power State	Symbol	Power Consumption (Typical)	Unit
Normal	I_{NORMAL}	70.6	mA
Suspend	$I_{SUSPEND}$	0.8	mA
Sleep	I_{SLEEP}	0.8	mA
Read	I_{READ}	108.3	mA
Write	I_{WRITE}	160.9	mA

3.0 Theory of Operation

3.1 Block Diagram

The industrial grade USB flash drive uses STEC's proprietary USB flash memory controller, and is combined with SLC NAND flash for optimal device reliability. The controller's firmware supports the latest NAND flash technology from multiple vendors, and is optimized for the highest performance and reliability.

The controller consists of the functional blocks as shown in Figure 3. The blocks are described in the paragraphs following the figure.

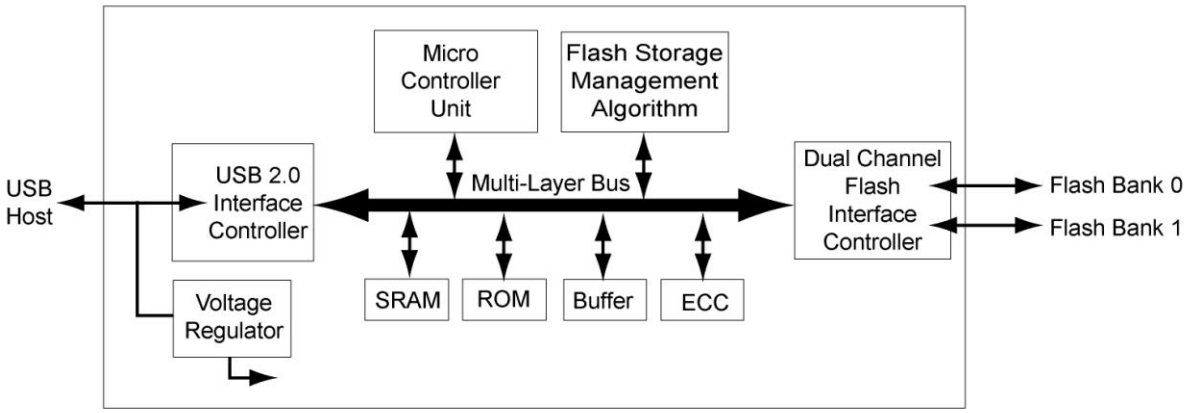

Figure 3: Controller block diagram

3.1.1 Controller Embedded Components

- *Microcontroller*, the hardware backbone for the USB flash memory controller algorithm.
- *USB 2.0 Interface Controller* with high speed (480 Mbps) device function. This block interfaces with the host system via the USB interface.
- *Flash Interface Controller* that serves as the interface to the NAND flash components. It supports all the major NAND flash memory manufacturers.
- *Flash Storage Management Algorithm Block* is responsible for the flash management, including wear leveling, bad block management, and Error Correction.
- *ECC* block is responsible for on-the-fly error and correction.
- *Sector Buffer* for optimized performance.
- *SRAM* for running controller firmware fast and efficient.
- *ROM* for storing controllers boot code.

3.1.2 Controller External Components

In addition to the functional blocks shown in Figure 3, the industrial grade USB flash drive has the following external components:

- *SLC NAND Flash* for the most reliable data storage.
- *Crystal Oscillator 12Mhz*, as the main clock source.

3.2 Flash Management

Since the industrial grade USB flash drive provides a standard USB interface to the host, no software integration is required, providing the shortest time-to-market for design engineers.

The firmware of the embedded USB 2.0 controller contains STEC's advanced flash memory management algorithms to ensure the most optimum device performance, reliability and endurance. It was designed to maximize the benefits of flash memory, while at the same time overcoming inherent NAND flash limitations. Implemented in firmware are the below features:

- Flash file system management
- Bad-block management
- Wear-leveling
- Performance optimization

3.2.1 Bad Block Management

Inherent to NAND flash technology are areas (blocks) on the media that cannot be used for storage because of their high error rate. These so-called "bad blocks" are already identified by the flash vendor during manufacturing, but can also be accumulated over time during device operation.

The USB flash memory controller contains a table that lists all the bad blocks on the device (Bad Block Table), and automatically maps out these blocks upon system initialization. During device operation it ensures that newly accumulated bad blocks are also mapped out and added to the Bad Block Table.

Bad block management is 100% transparent to the host application, which will not be aware of the location or existence of bad blocks on the media.

3.2.2 Wear Leveling

The SLC NAND flash devices that are being used in the industrial grade USB flash drive are rated for 100,000 Write/Erase cycles per block for 43nm flash and 60,000 Write/Erase cycles per block for 32nm flash. This means that after the rated erase cycles, the erase block has a higher probability for errors than the error rate that is typical to the flash. While standard flash write/erase cycles may be good for consumer data storage, such as digital cameras, MP3 players, etc., it is not sufficient for industrial and embedded applications where data is constantly written to the device and long product life is required.

For example, operating systems that use a file system, will update the File Allocation Table (FAT) every time a write is done to the device. Without any wear leveling in place, the area on the flash where the FAT table is located would wear out faster than other areas, reducing the lifetime of the entire flash device.

To overcome this limitation, the flash management algorithm needs to make sure that each block in the device ages, i.e. is "worn out", at the same rate. The built-in wear leveling scheme makes sure that with every write to the flash, the youngest block is used. This ensures that the full flash media is used uniformly, so that one area of the flash will not reach the endurance limits prematurely before other areas.

3.2.3 Error Correction/Detection

The USB 2.0 Interface Controller implements an advanced Error Correction scheme, based on the BCH error correct algorithm. The ECC engine can correct up to 16 bits per 1 KByte. To ensure the fastest performance, correction is done on-the-fly, in hardware only.

Each time the host application writes a sector of 512 bytes to the industrial grade USB flash drive, a unique ECC signature is created by the ECC engine and written together with the data to the flash. When the data is read back by the host, the ECC engine creates again the unique ECC signature. It will then compare the original written signature with the newly created signature, and sets an error flag if the two signatures are not the same. Correction of the data is done on-the-fly when the error flag is set, and the data presented to the host will be the same as the original written data an Uncorrectable Bit Error Rate (UBER) of less than 1 in 10^{14} bits, read.

3.3 OS Support

The industrial grade USB flash drive is recognized as a removable drive and supports the following Operating Systems, as listed in Table 5.

Table 5: Supported Operating Systems

Operating System	Version
Windows 98/2000/XP/Vista/Windows 7	
Windows XP Embedded	Service Pack 2007
Windows CE	4.2 and 5.0
Windows for POS (WEPOS)	
VxWorks	6.1 and up
Linux	Kernel 2.4 and up

Note: Windows 98 requires driver.

3.3.1 Using USB Flash Drive with XP Embedded

When using the industrial grade USB flash drive with Windows XP Embedded, it is recommended that the Enhanced Write Filter (EWF) feature is implemented. The EWF intercepts calls at the sector level, and thereby eliminates many file system updates/writes to the flash. Windows XP Embedded Service Pack 2 Feature Pack 2007 introduced an additional write protect feature, called File Based Write Filter (FBWF). The new FBWF function write-protects embedded devices at the file level, in contrast to the EWF, which has been protecting devices at the sector level.

FBWF and EWF, combined with the built-in wear leveling algorithm, ensure that the maximum life span of the flash device is achieved.

3.4 Unique Serial Number

During manufacturing stage, a unique serial number is written to the industrial grade USB flash drive that includes a date code related to the time of manufacturing.

The serial number uses the following format: [AA][B][C][DD][EE][FFFF][GGGG] Table 6 below describes the parameters of the serial number.

Table 6: Unique Serial Number format

Symbol	Parameter
AA	STEC Reserved (86h)
B	Year (hex)
C	Month (hex)
DD	Day (hex)
EE	Production PC Number (hex)
FFFF	Last 2 Bytes of MAC Address
GGGG	Serial Number, Incremental (hex)

Note: The Serial Number can be obtained through Windows Device Manager or Linux lsusb utility.

4.0 Environmental Specifications

4.1 Recommended Operating Conditions

Table 7: Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Commercial Operating Temperature	T_A	0	25	70	°C
Industrial Operating Temperature	T_A	-40	-	85	°C
Bus Voltage (5V)	$V_{BUS(5V)}$	4.75	5.0	5.25	V

4.2 Reliability

Table 8: Reliability

Parameter	Value	
Uncorrectable Bit Error Rate (UBER)	<1 uncorrectable error per 10^{14} bits read	
Endurance 1GB-4GB 8GB	 Up to seven (7) full drive capacity writes per day for three (3) years Up to five (5) full drive capacity writes per day for three (3) years	
Data Retention	Fresh: 10 years at 40°C	From Life End: 1 year at life end at 40°C
Durability	1500 insertions/removals	

Note: Endurance varies with usage, above numbers assumes a mix of 50% sequential and 50% unaligned random 4KB writes. All parts covered under 3-year warranty. Data Retention listed as specified by NAND flash manufacturer.

4.3 Shock, Vibration, and Humidity

Table 9: Shock, Vibration & Humidity

Parameter	Value
Shock	1500G Peak, 0.5m pulse duration, 5 pulses, 6 axes (per JESD22-B110)
Vibration	20G Peak, 20-2000 Hz, 4 cycles per direction (X, Y and Z) (per JESD22-B103)
Humidity	85°C, 85% RH, Vmax for 500 hrs (per JESD22-A101)

4.4 Electrostatic Discharge (ESD)

The industrial grade USB flash drive has been tested for immunity from ESD under the conditions described in Table 10.

Table 10: Electrostatic Discharge for UFD

ESD Type	ESD Rated Enclosure (Maximum Discharge)
Contact	8KV
Air	15KV

4.5 Mean Time Between Failure (MTBF)

STEC estimates Mean Time Between Failure (MTBF), using a prediction methodology based on reliability data for the individual components in the industrial grade USB flash drive. Table 11 summarizes the prediction results for the industrial grade USB flash drive, based on the following two methodologies:

- Telcordia Special Report SR-332, Reliability Prediction Procedure for Electronic Equipment.
- MIL-HNBK-217

The analysis was performed using Relex Software.

Table 11: USB Flash Drive MTBF

Product	Condition	MTBF (hours)
SLUFD4GU2TU	Telcordia SR-332, GB, 25°C MIL-HNBK-217	>4,000,000
SLUFD8GU2TU	Telcordia SR-332, GB, 25°C MIL-HNBK-217	>4,000,000

4.6 Standards Compliance

The industrial grade USB flash drive complies with the following standards:

- CE - EN 55022/55024
- FCC - Class B for Information Technology
- UL 60950
- RoHS-6
- USB 2.0 – Mass Storage Class

5.0 Electrical Specifications

5.1 Absolute Maximum Ratings

Operation not guaranteed at extreme corner cases.

Table 12: Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Power Supply Voltage Relative to Ground	V_{BUS}	-0.3 to 5.5V	V
Voltage on D+ and D- Relative to Ground	V_{DATA}	-0.3 to 3.6	V
Ambient Operating Temperature (Commercial)	T_A	0 to +70	°C
Ambient Operating Temperature (Industrial)	T_A	-40 to +85	°C
Storage Temperature	Tstg	-40 to +85	°C

5.2 DC Characteristics

Measurements at Recommended Operating Conditions, unless otherwise specified.

Table 13: DC Characteristics for Full-Speed Operation (T_A=25ºC, Vdd=5V, Vss=0V)

Parameter	Symbol	Test conditions	Min	Typ	Max	Unit
Supply Voltage	V_{BUS}		4.75	5	5.25	V
Input LOW Voltage	V_{IL}		-	-	0.8	V
Input HIGH Voltage	V_{IH}		2.0	-	-	V
Output LOW Voltage	V_{OL}	R_L of 1.5kΩ to 3.6V	-	-	0.3	V
Output HIGH Voltage	V_{OH}	R_L of 15kΩ to GND	2.8	-	3.6	V
Output Signal Crossover Voltage	V_{CRS}		1.3	-	2.0	V

Table 14: DC Characteristics for High-Speed Operation (T_A=25ºC, Vdd=5V, Vss=0V)

Parameter	Symbol	Test conditions	Min	Typ	Max	Unit
Supply Voltage	V_{BUS}		4.75	5	5.25	V
High Speed Idle Level	V_{HSOI}		-10	-	10	mV
High Speed Data Signaling High	V_{HSOH}		360	-	440	mV
High Speed Data Signaling Low	V_{HSOL}		-10	-	10	mV
Chirp J Level (differential Voltage)	V_{CHIRPJ}		0.7	-	1.1	V
Chirp K Level (differential Voltage)	V_{CHIRPK}		-0.9	-	-0.5	mV

5.3 AC Characteristics

Measurements at Recommended Operating Conditions, unless otherwise specified.

Table 15: AC Characteristics Full Speed

Parameter	Symbol	Min	Typ	Max	Unit
Rise Time	T_{FR}	4	-	20	ns
Fall Time	T_{FF}	4	-	20	ns
Differential Rise and Fall Time Matching	T_{FRFM}	90		111.11	%
Driver Output Resistance	Z_{DRV}	28	-	44	Ω

Table 16: AC Characteristics High Speed

Parameter	Symbol	Min	Typ	Max	Unit
Rise Time (10%~90%)	T_{HSR}	500	-	-	ps
Fall Time (10%~90%)	T_{HSF}	500	-	-	ps
Driver Output Resistance	Z_{HSDRV}	40.5	-	49.5	Ω

6.0 SCSI Command List

Table 17: SCSI Command List

Command List	OpCode	RBC	SPC-2	SPC-3
INQUIRY	12h	√	√	√
MODESENSE(6)	1Ah	√	√	√
MODESENSE(10)	5Ah	-	√	√
PREVENT/ALLOW MEDIUM REMOVAL	1Eh	√	√	√
READ(10)	28h	√	-	-
READ CAPACITY	25h	√	-	-
REQUEST SENSE	03h	-	√	√
START STOP UNIT	1Bh	√	-	-
TEST UNIT READY	00h	√	√	√
WRITE(10)	2Ah	√	-	-
VERIFY(10)	2Fh	√	-	-
SYNC CACHE	35h	√	-	-

7.0 Product Marking

The industrial grade USB flash drive will be shipped with standards compliance logos on the front label (Figure 4) and the manufacturing info on the back label (Figure 5), providing lot traceability and full access to the Bill of Material.

The back label of the industrial grade USB flash drive shows the BOM Assembly Number. Table 18 decodes the BOM Assembly Number into the manufacturing info.

7.1 Front Label

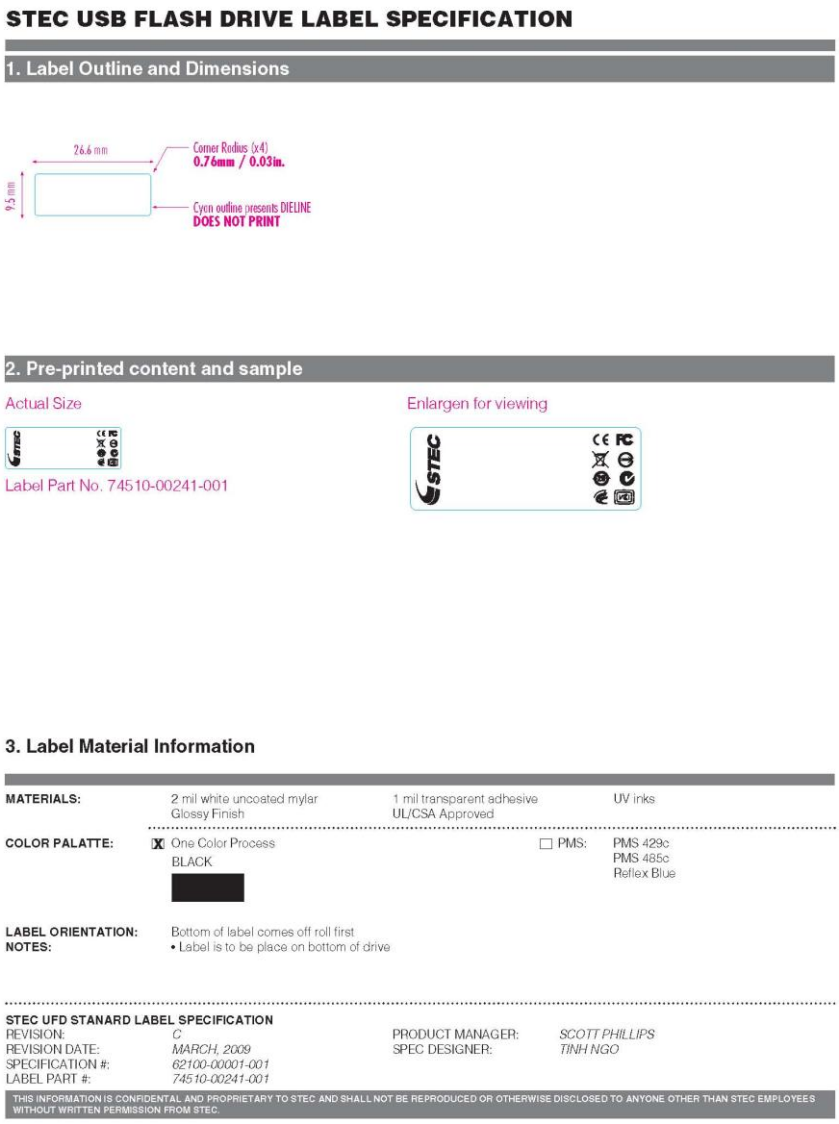

Figure 4: Front Label

7.2 Back Label

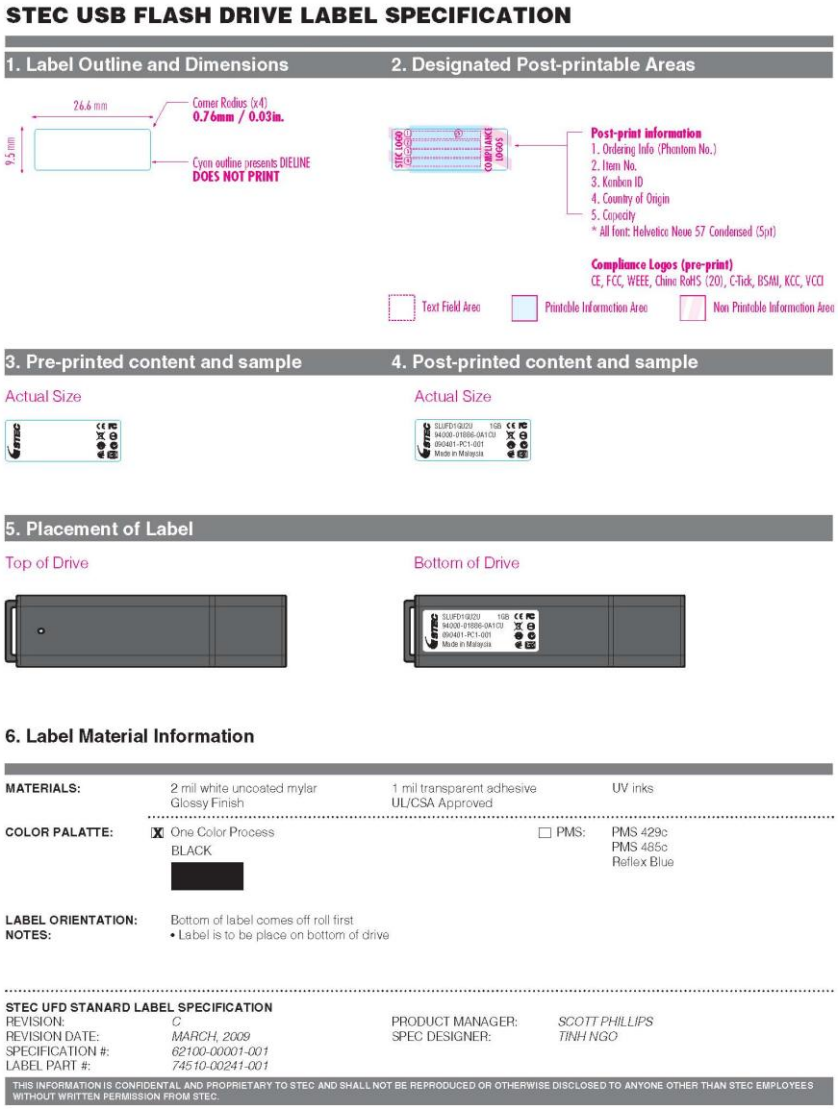

Figure 5: Back Label

7.3 Decoding the BOM Assembly Number

Table 18: BOM Assembly Number info

BOM Assembly Number (Format: ppp00-0xxxx-yyzT(C/I)U)	Description
ppp00	STEC designation for OEM Flash products (ppp is 940 for standard, or customer prefix for custom)
0xxxx	PCB number
yy	Product Revision
z	Capacity Designator (Randomly assigned per PCB number based on designator availability)
T	Model Revision
C, I	Commercial and Industrial Operating Temperature
U	RoHS Compliant

8.0 Programmed Vendor and Product Names

The the industrial grade USB flash drive can be manufactured with standard or customer-specific Vendor and Product Names. Table 19 lists the STEC standard names for the industrial grade USB flash drive.

The names can be displayed by the OS, for example, Windows XP displays the names in the notifications area in the right corner of the screen the first time the industrial grade USB flash drive is installed. Windows Device Manager and the properties of the the industrial grade USB flash drive also can display the names

Table 19: STEC Standard USB Vendor and Product Names

Parameter	Value
Vendor Name	“STEC”
Product Name	“STEC USB 2.0”

9.0 STEC's Contact Information

9.1 Worldwide Headquarters

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Pune - 411 008	
Telephone: +91-20-4678 0681	

10.0 Revision History

Revision	*Date*	*Description*
-101	02/14/2011	Preliminary release.
-102	02/23/2011	Label on photo of UFD updated. Extended changed to Industrial.Temperature. “T” designator added to BOM Assembly Number.
-103	04/08/2011	UBER, Endurance, and ECC Engine corrected (paper error only).
-104	04/26/2011	Photo edited to increased dpi. Preliminary notice removed.
-105	06/07/2011	Logo updated.
-106	05/31/2012	Endurance removed.
-107	09/10/2012	Endurance added. Data retention updated. Format updated. Trademarks clarified. Contact Information updated. ECC engine statement corrected.

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